Survey of the reptiles and amphibians of the montane forests near Tenterfield on the north coast of New South Wales

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ABSTRACT

Surveys were conducted in the area that formally encompassed the forests managed by the New South Wales Forestry Commission (Tenterfield Management Area). Surveys consisted of searches for reptiles along 35 transects, roadside searches, pitfall trapping and targeted surveys. Targeted searches were conducted for amphibians beside creeks, fire dams and swamps. A total of 33 species of reptile and 16 species of amphibian were detected. The highest species richness and density of reptiles occurred in eucalypt forests that contained rock outcrops. Closed forest had the lowest reptile species richness and density. Analysis of the abundance of two species of skink (accounting for 73% of observations) recorded during transect searches found that the Grass Skink *Lampropholis delicata* had greater abundances on logged plots than on unlogged plots whereas *Calyptotis scutirostrum* did not differ in its abundance across treatments. The Glandular Frog *Litoria subglandulosa* and Pugh's Frog *Philoria pughi,* species currently listed on the *Threatened Species Conservation Act (1995),* were detected during the surveys. The Masters Snake *Drysdalia rhodogaster* was detected and represents a 350 kilometre northern range extension of this species.

Key words: Tenterfield Management Area, reptiles and amphibians, impacts of logging.

Introduction

Regional surveys of fauna and flora provide an important step in our understanding of the conservation and management of species. Such surveys indicate the relative distributions and abundances of species in an area at a given time and can be used to evaluate possible habitat relationships, identify habitats or locations of regional significance and provide a baseline to monitor changes in population density and species diversity over time.

In the early 1990s, the then Forestry Commission of New South Wales (FCNSW) conducted a series of surveys of forests under its management (Newell and Goldingay 2004). These surveys were used to assess the impacts of logging activities through Environmental Impact Statements (EIS). The ability of these surveys to accurately assess such impacts has been debated (Resource Assessment Commission 1993, Milledge 1993, Newell and Goldingay 2004), however they did provide regional surveys of the fauna and flora and valuable baseline data. One of the areas of forest surveyed was located in the Tenterfield region of the north eastern escarpment of New South Wales (NSW) (Tanton 1995). The only other identified survey in these forests (Hines 1991) covered a small proportion of this area. Barker (1981) surveyed the herpetofauna in adjoining areas to the south in the area covering Gibraltar Range National Park, Billilimbra State Forest (SF), Dandahra Creek SF, Ewingar SF, Moogem SF and Washpool SF. Hence the EIS survey remains the only significant assessment of the forest herpetofauna in this region and provides a significant data set on which to base our understanding of the biodiversity in the region.

The aim of the present paper is to document the species of reptiles and amphibians that were detected during the EIS surveys and provide information on their broad locations and habitat associations. The relative abundance and distribution of reptiles was quantified by way of systematic surveys and we assess the influence of several identified environmental variables on these patterns. The survey methodology is reviewed in terms of the robustness of assessing the impact of logging on forest dependant species.

Methods

Location of study area

The study area lies within the former Tenterfield management area, situated on the north of NSW between 28° 20' and 29° 40'latitude and 151°30' and 152°50' longitude (Figure 1; Tanton 1995). The area was bounded by the Timbarra River to the east, Clarence River and the Queensland border to the north and the Dumaresque, Mole and Deepwater Rivers to the south. The area covered approximately 80,000 hectares and included Girard, Forest Land, Bookookoorara, Spirabo, Boonoo, Jenner, Giligurry, Malara, Girard and Girard extension State Forests. Some of these areas have now come into the reservation system as a result of a regional forest agreement.

Geology and soils

The soils in the study area were derived from five rock types that include metasediments, sediments, volcanics, corse-grained granites and fine-grained granites (Veness and Associates 1994). The most fertile soils were derived from volcanic rocks and the least fertile from granites.

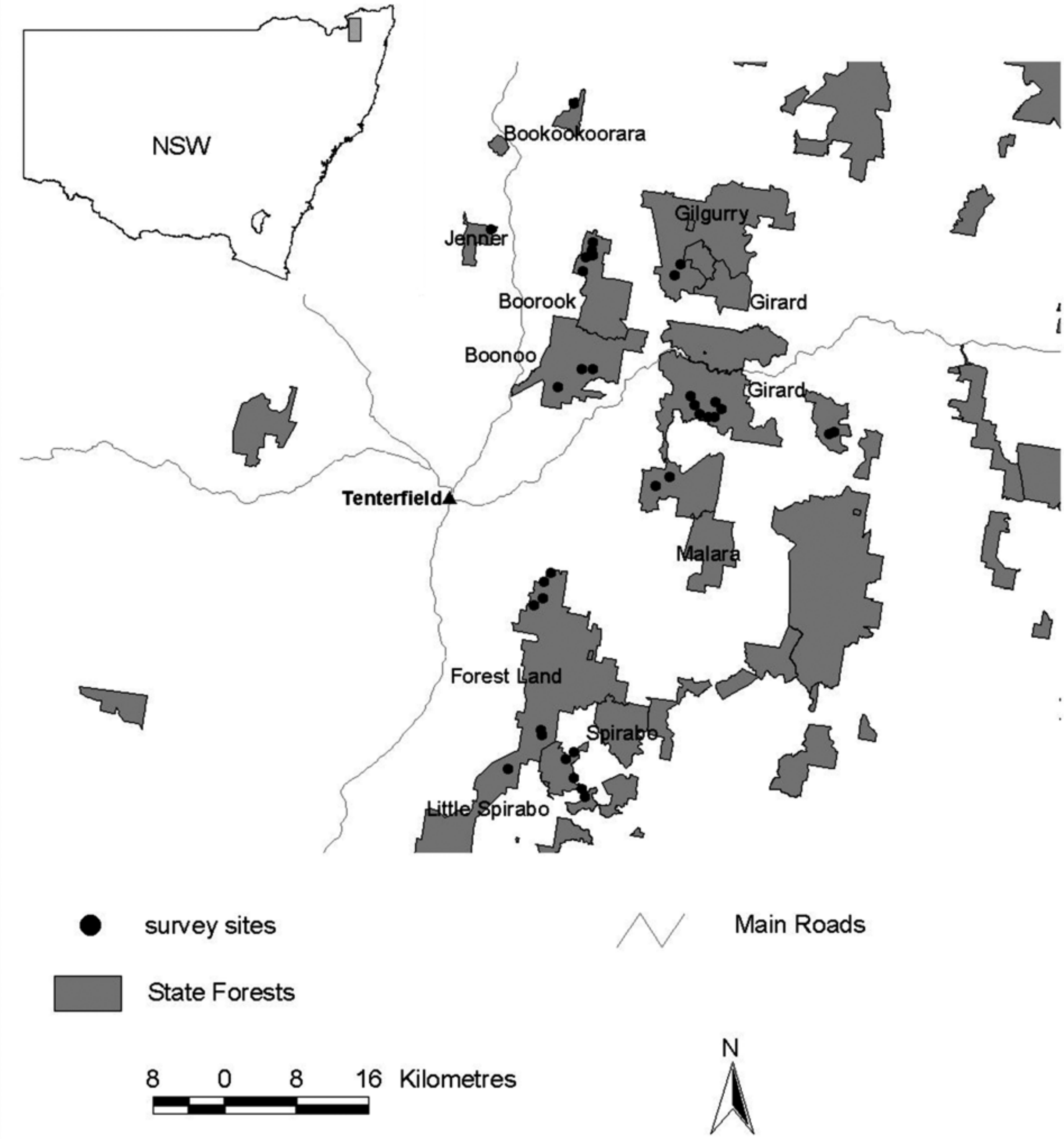

Figure 1. Location of the reptile transects surveyed in the Tenterfield management area.

Vegetation communities

The forest type varied from closed forest to open forest. Descriptions of vegetation communities are based on field observations and Binns (1995). The closed forest (CF) varied from warm temperate forest containing Coachwood *Ceratopetalum apetalum* - Sassafras *Doryphora sassafras* (Forest Land SF) to subtropical rainforest containing Yellow Carrabeen *Sloanea woollsii* often with Walkingstick Palm *Linospadix monostachya* understorey (Girard SF). Closed forest also occurred in the midcanopy of the moist hardwood forest dominated by Brushbox *Lophostemon confertus*. Other moist hardwood forest associations included Tallow-wood *Eucalyptus microcorys* – Blue Gum *E. saligna*. The mesic tablelands forests included New England Blackbutt *E. andrewsii*– *E. brunnea* – and Messmate *E. obliqua*. The dry tablelands forest included *E. andrewsii*, Broad-leaved Stringybark *E. caliginosa* and Narrow-leaved Peppermint *E. radiata*. These lower and or drier areas supported coastal forests with canopy species including Tallow-wood, Stringybark *E. eugenioides*, *E. saligna* and Spotted Gum *Corymbia maculata*. The open forests had a grassy understorey and were regularly burnt and subject to occasional grazing.

Other vegetation associations that were sampled during targeted surveys included sedgelands/heaths. Sedgelands/heath occurred in drainage depressions in Forest Land, Spirabo, Boonoo and Girard SF's. Common species in the sedgelands were *Fimbristylis nutans*, *Eleocharis dietrichiana* and *Carex* spp. The heathlands contained Teatree *Leptospermum* spp. and *Baeckea* sp.

Survey methods for reptiles

Surveys were based on methodology devised by the Forestry Commission of New South Wales (FCNSW) (York *et al.* 1991) with the main effort being centred around 35 x 500 m long transects placed within the broad forest types as determined by FCNSW and further categorised by logging history (Tables 1 and 2). The forests had been logged since 1860's (FCNSW 1983) with varying intensity with older style logging being generally less intense than more recent logging operations. Transects were located in unlogged, selectively logged and heavily logged (recent logging) stands, noting that "unlogged" sites may have been selectively logged between 1860 and 1930. Selective logging generally involved the removal of between 20-30% of the canopy and occurred between 1930-1985. Heavily logged sites generally had canopy reduction up to 50% and occurred from 1978-1991 (D. Coombe pers. comm.). The use of canopy species to distinguish forest type meant that the survey also sampled reptile species diversity and density with respect to soil moisture content.

Transects were separated by a minimum of 800 m (usually several kilometres) and located within 50-100 m of access roads. The location (Australian Geodetic Datum 1966) of sites was taken from topographic maps (Appendix 1). Elevations of reptile transects ranged from 430-1140 m (mean 911 m).

Transect surveys for reptiles were conducted between 0833 and 1618 h EST between 4th - 22nd February 1992. Two observers systematically walked along each transect to search 15 m either side of the midline observing animals as they basked or foraged and lifting loose rock and logs, decorticating bark and searching leaf litter to uncover animals. The intensity of each search technique varied according to availability of cover. Each transect search took 45 min, leading to 90 min search effort per transect, covering approximately 1.5 hectares. Fifty-two and a half hours of effort were spent searching transects for herpetofauna. Eight transects contained outcrops of granite; two of these were unlogged and six were logged. In addition to the transect searches, a 30 min search (15 min per surveyor, totalling 17.5 h search effort) was conducted beside the nearest road verge over approximately 0.5 hectares, within 100 m of the transects.

Two wet pitfall traps (10 litre buckets) were placed at intervals of 100 m along each transect giving a total of 10 pitfall traps per site. The pitfalls were partially filled with 10% formalin and set for 14 days. We recognise that this technique is now considered ethically inappropriate and would not be permitted under animal ethics licences today. However, the technique was used for this survey and we provide information on the efficacy of this method.

Targeted searches were also conducted at two granite outcrops found in Forest Land and Spirabo SF (60 min search effort by two people) to detect reptiles under loose rock. Surveys of swamps were conducted beside Spirabo Forest Way and other roads in Forest Land and Spirabo

Table 1. Area, elevation, and vegetation communities of survey sites by State Forest in the Tenterfield management area of New South Wales.

State Forest	Total area (hectares)	Reptile sites	Min. elevation	Max. elevation	Mean elevation	Closed forest	Tall open forest	Mesic tablelands	Dry tablelands	Coastal forests
Bookookoorara	802	1	875	875	875			(1)		
Boonoo	7101	4	870	1105	979		(1)	1	2(1)	
Boorook	4620	4	905	980	940		1	(1)	2(1)	
Forest Land	19308	7	975	1070	1039	2		5(4)		
Gilgurry	11190	2	680	690	685				1	
Girard	15426	7	570	965	754	2	5 (2)			
Girard extension	6257	2	430	560	495					2
Jenner	1035	1	975	975	975					(1)
Malara	3349	2	950	1035	993		(1)		(1)	
Spirabo	13071	5	985	1140	1095		4(2)	1		
Total	82159	35								

n = total number of sites, (n) = number of logged sites

Table 2. Vegetation communities sampled showing logging history.

Community	Number of sites	Logging history	Number with rock outcrops
Closed forest	4	4U	0
Tall open forest	8	4U, 2S, 2H	0
Mesic tablelands forest	12	4U, 4S, 4H	1S, 1H
Dry tablelands forest	7	3U, 4H	2U, 4H
Dry coastal forests	4	2U, 2S	0
Total	35	17U, 8S, 10H	8

U = unlogged, S = selectively logged, H = heavily logged

SF's (Five Bull and Burra Swamps) and along Scrub Road (between Tenterfield and Forest Land SF). Reptiles were also recorded opportunistically while conducting nocturnal frog searches and drive transects travelling to and from survey sites.

Nocturnal surveys for frogs

Road drive transects were conducted for frogs in Forest Land, Spirabo, Girard, Boonoo and Boorook SF's for a total of 18 nights. This involved slowly driving along a road during periods of rainfall (rain fell regularly throughout the survey period) and watching for animals illuminated by vehicle headlights. A total of 60 h were spent conducting nocturnal drive surveys.

Targeted nocturnal searches were conducted in swamplands and beside creeks and dams. These involved listening for calling males (5-10 min) followed by searches of the water bodies and adjacent bank and vegetation to detect and record the individuals and species present at each site. Sites were searched for a minimum of 10 min and more usually at least 30 min. Areas surveyed included Basket and Bark Hut swamps and a quarry in Boonoo SF. Several dams were surveyed in Girard SF Forest Land and Spirabo (Scrub Creek picnic area and the Coolamangera Scrub).

Analysis of transect data

For each 90 min 500 m transect search the total number of reptile species (i.e. species richness) observed and the total number of individuals of each species were tallied. The limited number of replicates available and the confounding effects of variation within replicate plots raises significant questions over an analysis of the data in regards to broad forest types and the impacts of logging. Only broad associations based on visual assessment of the graphed/tabulated data are presented.

Results

Ninety minute transect searches

The 90 min searches along the 35 transects (Table 3) detected 1504 individuals covering 23 species during 52.5 hours. Targeted searches, captures in pitfall traps and opportunistic observations revealed an additional seven species (Appendix 2). The most common reptile found was the Grass Skink *Lampropholis delicata* that accounted for 62% of all observations. *Calyptotis scutirostrum* accounted for 11% of observations. Snakes, goannas and dragons were infrequently detected and no geckoes were found during the systematic searches.

Reptile species richness ranged from 2-9 per transect. The average species richness varied with respect to vegetation community and logging history. The highest average species richness was found at unlogged dry tablelands forest, the lowest in unlogged closed forest. There was an apparent increase in mean species richness with an increase in disturbance when comparing the mean counts at unlogged versus logged sites and the highest species diversity at a single site occurred at a heavily logged transect (Table 4). The presence of rock outcrops increased average species richness regardless of logging history, especially in heavily logged sites. A number of reptile species were highly associated with rock outcrops, including Cunningham's Skink *Egernia cunninghami*, Red-throated Skink *Acritoscincus platynota* and Copper-tailed Skink *Ctenotus taeniolatus*.

Five species of frog were detected during the 90 min transect surveys. They were the Bleating Tree Frog *Litoria dentata* (dry coastal forest in Gilgurry SF), Glandular Tree Frog *Litoria subglandulosa* (dry coastal forest in Spirabo SF), Red-backed Toadlet *Pseudophryne coreacea* (dry coastal forest in Boorook SF), Great Barred Frog *Mixophyes facsiolatus* and Fletcher's Frog *Lechriodus fletcheri* (latter two species in closed forest in Forest Land SF).

Analysis of common reptile species

The number of *L. delicata* observed during individual transect searches ranged from one to 188 animals. *Lampropholis delicata* was detected on all transects and was more abundant on sites that had the most recent disturbance that were selectively logged (Figure 2). Few *L. delicata* were observed in closed forest (mean = 5.25, SE = 7.4) and the highest number was in logged mesic tableland forests (mean = 44.25, SE = 47) (Figure 3). *Calyptotis scutirostrum* was detected on 54% of transects and was absent from closed forest. Its highest observed densities occurred in unlogged or slightly logged dry coastal forest (mean =24, SE = 0.7), but there was no observable pattern in its abundance between logged and unlogged sites (means of logged v/s unlogged were equal at 4.8).

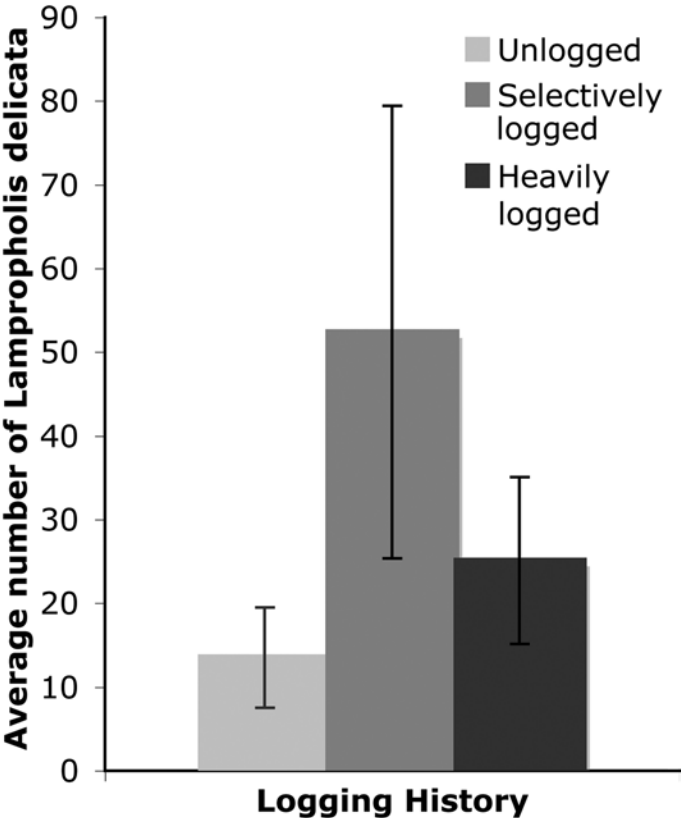

Figure 2. Mean number of *Lampropholis delicata* observed in relation to logging intensity.

Table 3. Species of reptiles detected during 90 minute transect surveys within State Forest of the Tenterfield Management Area.

Family	Species	Common name	Bookookoorara	Boonoo	Boorook	Forest Land	Gilgurry	Girard	Girard ext	Jenner	Malara	Spirabo	No. of transects	No. of individuals
Varanidae	*Varanus varius*	Lace Monitor							1				1	1
Gekkonidae	*Oedura tryoni*	Spotted Velvet Gecko				opp								
Agamidae	*Amphibolurus nobbi nobbi*	Nobbi Dragon						opp						
	Physignathus lesueurii lesueurii	Eastern Water Dragon						1					1	1
Scincidae	*Acritoscincus platynota*	Red-throated Skink		2	1						1		4	4
	Anomalopus leukartii								1				1	1
	Bellatorias major	Land Mullet							opp					
	Calyptotis scutirostrum	Scute-snouted Calyptotis	9	6	41	1	37	18	31	1	25	0	19	169
	Ctenotus taeniolatus	Copper-tailed Skink		4									1	4
	Egernia cunninghami	Cunningham Skink		3							4		4	7
	Egernia mcpheei	McPhee Rock Skink		24			2	1			2	5	9	34
	Eulamprus martini	Dark Bar-sided Skink		10	10		5	5	7	20	8		13	65
	Eulamprus murrayi	Blue-flecked Forest Skink				31		8				14	13	53
	Eulamprus quoyii	Eastern Water-skink		1		23						121	11	145
	Eulamprus tenuis	Barred-sided skink					1						1	1
	Lampropholis delicata	Grass Skink	52	75	150	365	40	46	9	19	53	121	35	930
	Lampropholis guichenoti	Garden Skink			2						5		2	7
	Liopholis whitii	Whites Skink		1	4								2	5
	Saiphos equalis	Three-toed Skink		2	2	9	1			1		1	8	16
	Saproscincus rosei	Orange-tailed Skink	1		1	33		6				4	13	45
	Saproscincus mustelina	Weasel Skink				3							3	3
Boidae	*Morelia spilota mcdowelli*	Carpet Python						opp						
Elapidae	*Cacophis krefftii*	Dwarf Crown Snake										1	1	1
	Cacophis squamulosus	Golden Crown Snake					1					1	1	2
	Hemiaspis signata	Swamp Snake	1			2						3	3	6
	Drysdalia rhodogaster	Masters Snake				opp								
	Rhinoplocephalus nigrescens	Small-eyed Snake			2	opp							2	2
Typhlopidae	*Ramphotyphlops nigrescens*	Black Blind Snake			2								2	2
		Total Species	4	10	10	8	7	7	5	4	7	9		
		Total Individuals	63	128	215	467	87	85	49	41	98	271		1504
		Total Sites	1	4	4	7	2	7	2	1	2	5	35	

opp - observed opportunistically or during targeted surveys.

Table 4. Mean species richness of reptiles detected during the 90 minute transect searches in relation to vegetation communities, sites with rock outcrops and logging history.

Community	Unlogged	Selectively logged	Heavily logged	Average
Closed Forest	2.3 (4)	no samples	no samples	2.3 (4)
Moist Hardwood	2.8 (4)	3.0 (2)	3.5 (2)	3.0 (8)
Mesic Tablelands Forest	4.3 (4)	6.0 (4)	4.5 (4)	5.0 (12)
Dry Tablelands Forest	6.7 (3)	no samples	6.5 (4)	6.6 (7)
Coastal Forests	4.0 (2)	5.5 (2)	no samples	4.8 (4)
Average	4.0 (17)	4.8 (8)	4.8 (10)	
Plots with Rock outcrops	7.5 (2)	6.0 (1)	6.2 (5)	6.6 (8)
Plots without rock outcrops	3.3 (15)	5.0 (7)	4.0 (5)	4.1 (27)

(N) = number of sites

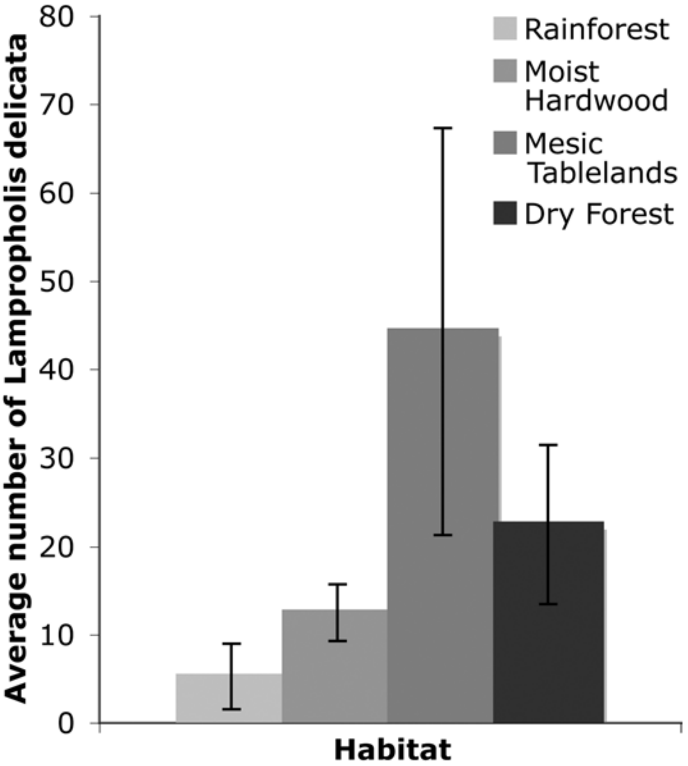

Figure 3. Mean number of *Lampropholis delicata* observed in various forest types.

Pitfall trapping

Nine species of reptile and one species of frog were caught in pitfall traps (Table 5). A total of 136 reptiles were trapped consisting of one species of dragon and eight species of skink. The most common caught species was the Eastern Water Skink *Eulamprus quoyii* (46% of captures) and *L. delicata* (21% of captures). The skink *Lampropholis amicula* and the Pugh's Frog *Philoria pughi* were only detected by capture in pitfall traps.

Thirty minute roadside searches

A total of 445 individual reptiles covering 11 species were observed during the 17.5 hours of roadside searches (Table 6). The most common animal was *L. delicata,* accounting for 74 % of observations. *Eulamprus quoyii* accounted for 12% and *C. scutirostrum* 6% of observations. During one search 205 *L. delicata* were observed, giving a density of approximately 410 animals per hectare. The majority of these lizards were juveniles. Two species, the Land Mullet *Bellatorias major* and the Nobbi Dragon *Amphibolurus nobbi* were detected during these surveys, but not during the ninety minute transect searches.

Targeted searches of specific habitat and opportunistic sightings

The spotted velvet gecko *Oedura tryoni* and Masters Snake *Drysdalia rhodogaster* were detected during targeted surveys of granite rock outcrops in Forest Land SF. These species were not detected by other survey methods. A further ten species were observed during searches of granite outcrops (Table 3, Appendix 2).

Searches of various swamps in Spirabo SF detected eight species of reptile and one species of frog. Searches of rocky outcrops near Basket Swamp in Boonoo SF revealed six species of reptile and four species of frog. The Carpet Python *Morelia spilota mcdowelli* was observed opportunistically in Girard SF and examination of the gut contents of a road killed animal revealed two Sugar Gliders *Petaurus breviceps.*

Nocturnal surveys for frogs

A total of twelve species of frog were detected during nocturnal searches. The majority of records were of males calling around water bodies, although road drive transects also facilitated the detection of some dispersing animals (Table 7).

Discussion

Species diversity and density

This study recorded 33 species of reptile and 16 species of frog within the Tenterfield forests and represents a baseline to which future surveys in the region can be compared. This is comparable to a study that was conducted in the adjacent Gibraltar Range area where 32 species of reptile and 14 species of frog were recorded (Barker 1981).

No turtles or legless lizards were detected during the current survey. The absence of turtles was considered a result of the few creeks in the area and limited time spent searching suitable habitat. The absence of legless lizards is probably a reflection of the population density of these species in this area. However, the

Table 5. Reptiles and amphibians caught in pitfall traps within various State Forests of the Tenterfield Management Area.

Family	Species	Common name	Bookookoorara	Boonoo	Boorook	Forest land	Gilgurry	Girard	Girard ext	Jenner	Malara	Spirabo	No. transects	No. individuals
Agamidae	*Amphibolurus muricatus*	Jacky Dragon								1			1	1
Scincidae	*Calyptotis scutirostrum*	Scute-snouted Calyptotis			2	1							3	3
	Eulamprus murrayi	Blue-flecked Forest Skink				11						13	6	24
	Eulamprus quoyii	Eastern Water-skink				7						55	8	62
	Lampropholis amicula	Small Grass Skink						2					1	2
	Lampropholis delicata	Grass Skink	1	1	6	9		1				11	11	29
	Lampropholis guichenoti	Garden Skink									2		1	2
	Saiphos equalis	Three-toed Skink				1						2	3	3
	Saproscincus rosei	Orange-tailed Skink				9						1	5	1
Limnodynastidae	*Philoria pughi*	Pugh's Frog										1	1	1
		Total Species reptile	1	1	2	6		2		1	1	5		
		Total Individuals reptile	1	1	8	38		3		1	2	82		128
		Total Sites	1	4	4	7	2	7	2	1	2	5		

Table 6. Species of reptiles detected during 30 minute roadside surveys within State Forests of the Tenterfield Management Area.

Family	Species	Common name	Bookookoorara	Boonoo	Boorook	Forest land	Gilgurry	Girard	Girard ext	Jenner	Malara	Spirabo	No. of transects	No. of individuals
Agamidae	*Amphibolurus muricatus*	Jacky Dragon		1									1	1
	Amphibolurus nobbi	Nobbi Dragon				2		1					2	3
Scincidae	*Bellatorias major*	Land Mullet				0		2					2	2
	Calyptotis scutirostrum	Scute-snouted Calyptotis	1	2	8	1	1	0	7	0	8	0	11	28
	Eulamprus martini	Dark Bar-sided Skink		2	3	1	3			2	2		9	13
	Eulamprus murrayi	Blue-flecked Forest Skink				0		1					1	1
	Eulamprus quoyii	Eastern Water-skink				9						44	8	53
	Lampropholis delicata	Grass Skink	10	10	229	31	8	4	2	2	14	18	27	328
	Saiphos equalis	Three-toed Skink				5							4	5
	Saproscincus rosei	Orange-tailed Skink				8		1				1	4	10
Typhlopidae	*Ramphotyphlops nigrescens*	Black Blind Snake				0						1	1	1
		Total Species	2	4	3	7	3	5	2	2	3	4		
		Total Individuals	11	15	240	57	12	9	9	4	24	64	5	411
		Total Sites	1	4	4	7	2	7	2	1	2	5	35	

Table 7. Species of amphibian detected during surveys within State Forests of the Tenterfield Management Area.

Family	Species	Common name	Bookookoorara	Boonoo	Boorook	Forest land	Gilgurry	Girard	Girard ext	Jenner	Spirabo
Hylidae	*Litoria chloris*	Red-eyed Tree Frog						o			
	Litoria dentata	Bleating Tree Frog			h	h	h		h		
	Litoria fallax	Dwarf Tree Frog							o/h		
	Litoria subglandulosa	Glandular Frog									t
	Litoria latopalmata	Broad-palmed Frog		o							
	Litoria wilcoxii							o			
	Litoria peronii	Peron's Tree Frog		h		h		h			
Limnodynastidae	*Lechriodus fletcheri*	Fletcher's Frog				t,o		o			o
	Limnodynastes peronii	Striped Marsh Frog				o		o		o	
	Limnodynastes dumerilii	Pobblebonk				h					
	Philoria pughi	Pugh's Frog									p
Myobatrachidae	*Crinia signifera*	Common Eastern Froglet		h	h	h		h			
	Crinia parinsignifera	Eastern Sign-bearing Frog		h		h		h			
	Mixophyes fasciolatus	Great Barred Frog				t,o		h			
	Pseudophryne coriacea	Red-backed Toadlet			o	o		o			o
	Uperoleia laevigata	Toadlet		h		h					
		Total Species		5	3	1	1	9	2	1	4

o = observed, h = heard, p = pitfall specimen, t = observed during foot transect surveys, clear cells represent no detections.

result was surprising given several scaly foot *Pygopus lepidopodus* and two Burton's Legless Lizard *Lialis burtonis* were caught during the Barker (1981) survey by one of us (GD) in areas adjacent to heathland/swamps that contained granite outcrops and open forest (GD pers. obs.). Since this habitat type was present in the Tenterfield forests it is anticipated that further surveys will reveal these species exist in the area. Other species that Barker (1981) detected that may occur in the Tenterfield forests include the Southern Leaf-tailed Gecko *Saltuarius wyberba*, Major Skink *Egernia frerei*, Alpine Water Skink *Eulamprus kosciuskoi*, Yellow-faced Whip Snake *Demansia psammophis*, Red-bellied Black Snake *Pseudechis porphyriacus*, Eastern Tiger Snake *Notechis scutatus* and Bandy-bandy *Vermicella annulata.* Most of these were recorded during the North East Forests Biodiversity Study in the Tenterfield area (NPWS, 1994 a, b and c), which are presented with other incidental records sourced from a search of the atlas of New South Wales wildlife in Appendix 2.

The amphibians detected during our surveys were typical for the region of north-eastern NSW. Other species that Barker (1981) detected in the Washpool area that may occur in the Tenterfield forests include the Hip Pocket Frog *Assa darlingtoni,* Giant Barred Frog *Mixophyes iteratus,* Leaf-green Stream Frog *Litoria barringtonensis* and Verreaux's Frog *L. verreauxii.* It is acknowledged that no stream-side nocturnal spotlight searches or call playback were conducted during this assessment and this impacted on results. It is also acknowledged that species such as members of the *Philoria* genus call primarily in spring (Lemckert and Mahony 2008) and were unlikely to be detected by calls during our summer survey.

Only nine species were captured in the pitfall traps. Hand searches on transects found 22 species and 11 species along roadsides. When compared to hand searches, pitfall trapping revealed only one additional species (*Lampropholis amicula*) not observed (or identified) during hand searches. Wet pitfall trapping can not be justified as it resulted in the death of many animals for comparatively little data. Wet pitfall trapping for vertebrates is currently not allowed by the Department of Agriculture Animal Ethics Committee.

Granite outcrops had the highest species richness of reptiles. This habitat allowed a higher degree of sunlight to reach the ground than in vegetation communities with dense canopies. The amount of direct sunlight and the properties of rock to store and radiate heat and provide refuge sites (especially loose rock on rock) were considered significant biophysical components that catered for certain species of reptiles as has been demonstrated in rock outcrops further south in NSW (Pike *et al.* 2011). This correlation between elevated reptile species richness with exposed rock outcrops has been noted for other regions in New South Wales (Daly 2004, 2006 and 2007).

Impacts of logging

The impacts of logging on reptiles was assessed through a comparison of the transect data in the Tenterfield EIS (Tanton 1995), however we have not attempted to include a comparative analysis because of concerns over several features of the data. Such analyses may be misleading because pooled data are dominated by a small number of taxa (Goldingay *et al.* 1996 Newell and Goldingay 2004). The basic approach used by York *et al.* (1991) is sound, especially in regards to the amount of survey effort per transect. However, the value of any assessment is dependent on the level of site replication used and the quality of the replicates. In our case, the environmental variation between replicates within a treatment often appeared to be high. The main environmental variables within sites were:

- Transects in dry forest would sometimes cross gullies with moist vegetation, leading to moist forest reptiles being recorded in a dry forest transect.
- The presence of rock outcrops in some transects, but not others, caused major variations in the numbers and types of reptiles being recorded.
- The actual intensity of logging sampled appeared to vary between transects within the same logging history category.
- Some sites appeared to be affected by fire more than others and the use of fire as a co-variate in any analysis would appear necessary to account for its effect.
- Wet pitfall surveys overlapped transect sampling at some (12) sites (those in Forest Land and Spirabo SF). The number of days that the pitfalls were open in relation to when we surveyed varied. Animals caught in pitfall traps were removed from the population within the immediate area where diurnal reptile surveys were conducted. Hence, the number of animals (especially *E. quoyii*) detected on some transect surveys were less than would have been found if pitfall trapping had been conducted after systematic surveys.

Given the above issues, replicates within each treatment were relatively variable, thus confounding comparisons to at least some degree and were sufficient for us to believe that a statistical analysis of logging impacts should not be undertaken. Instead, we only looked at broad trends of potential logging impacts evident through visual inspection of graphed and tabulated data for the most common species. The suggestion from this approach was that logging had a positive impact on the density of *L. delicata,* but not *C. scutirostrum*. Lunney *et al.* (1991) found *L. delicata* and *L. guichenoti* were impacted to a minor extent by integrated logging but had significantly reduced abundances in forest where timber stand improvement (clear-felling) had resulted in dense regrowth. Goldingay *et al.* (1996) found an increase in abundance of some species of skink (*E. heatwolei, E. tympanum* and *Pseudemoia spenceri*) following logging but not others (i.e. *Nannoscincus maccoyi*). The increase in density of some species of skink can be attributed to increased solar radiation and the greater abundance in logs/branches and leaf litter following logging. The provision of microhabitat and the increase in direct sunlight appears to be factors attributed to the greater abundance of species of skink that utilise fallen timber and leaf litter. The lack of response by *C. scutirostrum* is probably related to the fossorial habitat of this species. This may have also been the case for *N. maccoyi* in the Goldingay *et al.* (1996) study. Where regrowth is dense sunlight penetration is likely to be less than unlogged forests.

On the basis of our work, future surveys that aim to assess the impacts of logging on reptiles should use a larger number of smaller transects that are relatively homogeneous (lack rock outcrops and have a consistent logging, fire history and or intensity). Ensuring that each transect or sample area falls within a uniform and replicated environment will greatly reduce the effects of inconsistent habitat variables and make interpretation of collected data considerably simpler. A further improvement would be repeated sampling of sites to reduce the variation in the data. Multiple samples, preferably three or four, will provide a closer approximation of the true number of species and individuals present at each site and so provide data more capable of distinguishing site similarities and differences. It is also evident that it is never going to be possible to collect sufficient data from such studies to assess the impacts of logging or other human activities on rarely recorded species. For these less common forest dependant species it may be far more beneficial to conduct targeted studies including radio-telemetry work (Fitzgerald *et al.* 2002).

Assessment of survey methods

Various survey methods have been used to assess the impact of logging on reptiles in Australia. These include pitfall trapping (Webb 1995) and searches for animals along transects (Lunney *et al.* 1991, Brown and Nelson 1993 and Goldingay *et al.* 1996, Newell & Goldingay 2004). In the studies that rely on transect searches there is a variation in the method used to secure adequate replication. In some surveys there was repeat sampling of plots and in others a greater number of plots are sampled to gain adequate data for analysis. Irrespective of sampling strategy, results from the above case studies indicate that only common species are likely to be regularly detected in large numbers and at numerous sites. Hence, such surveys can provide information on broad distributions in a region and some information on habitat associations and relative status, but they have little value in quantifying human impacts on rare forest dependant species. Even for relatively common species there can be a large variation in abundance over altitude (Daly 2007), which can confound data. We concur with Newell and Goldingay (2004) that although a key aim of the SFNSW Environmental assessment process was to assess the response of individual species to disturbance (logging), few of the studies conducted could actually achieve this. There is an opportunity to undertake retrospective power analyses from these and other EIS data to provide a more detailed indication of the level of replication that would be required to make impact assessment feasible.

Reproductive seasonality of reptiles is an important factor to consider when designing quantitative surveys as studies conducted over the time when young are born or eggs hatch can greatly inflate counts. Reptiles in subtropical and temperate regions of Australia generally breed in spring and give birth or their eggs hatch in late summer to early autumn (Greer 1989). The current survey was conducted during a period when the common skinks had either given birth (i.e. *E. quoyii*) or their eggs had hatched (i.e. *L. delicata*). Our results may have been compromised as the number of juvenile animals may have varied from the start to the end of the sampling period, although all transects were sampled within a relatively short time span and should have equally likely contained that year's young. The variation in number of animals detected because of the presence of recently born or hatched juveniles also meant that counts would be higher than if the surveys were conducted during other seasons. However, we acknowledge a possible advantage of surveying at such time as species that persist in low densities may be more detectable with the influx of juveniles.

The current survey sampled amphibians by pitfall trapping and by targeted searches of water bodies. No systematic stream side searches were conducted and the coverage of available breeding sites was opportunistic. Given these restrictions a relatively large number of species were found. However, only two threatened species were detected. The surveys were not ideally timed as February is a poor time to survey *Philoria* spp. and *Litoria subglandulosa*, which are noted spring callers (Cogger 2000; Lemckert and Mahony 2008). Surveys need to be conducted over a range of nights and in a range of seasons in order to detect all species present and to account for the influence of climatic conditions on detectability. Call playback and tadpole sampling are relatively recent methods used to detect rare species and habitat specialists (eg, Daly *et al.* 2001, Daly *et al.* 2002, Daly and Craven 2007). However, at the time of our surveys the use of such methods was rudimentary.

Habitat specialists and zoogeographic patterns

There are several suites of reptiles and frogs that are considered to occupy specialist habitats. The saxicolous species include the reptiles *Oedura tryoni, Acritoscincus platynota, Ctenotus taeniolatus, Egernia cunninghami* (northern NSW granite form), *E. mcpheei, Lyopholis whitii* and *Eulamprus martini* that were highly associated with granite outcrops and granitic substrates. The granite outcrops are a significant habitat component in Gibraltar Range of northern NSW including Tenterfield forests.

Another suite was highly associated with closed forests and tall open forest with closed forest midcanopy. These "mesic" species included *Bellatorias major, Eulamprus murrayi, Saproscincus rosei* (Sadlier *et al.* 1993, Swan *et al.* 2004), *Mixophyes facsiolatus, Lechriodus fletcheri* and *Philoria pughi.*

Range extensions - limits of distribution

Drysdalia rhodogaster had not previously been recorded in the study area and is a range extension of some 350 kilometres north from the Newnes plateau (Swan *et al.* 2004). Two specimens were detected under loose granite rocks. One appeared to be a gravid female. Both specimens exhibited typical colour patterns for this species being olive brown dorsally and yellow ventrally with a dark head. Although no voucher specimens were taken, we are confident of the identification as both authors observed one animal and are familiar with this species.

Other reptiles detected during the current survey that represent small western range extensions include *Cacophis krefftii, Bellatorias major* and *Egernia mcpheei. Egernia cunninghamiana* has long been recognised as a composite species (Wells and Wellington 1983). The animals detected during the current survey are described as the northern Tablelands form (Swan *et al.* 2004), which has a distribution that includes the granite outcrops of the Tenterfield SF and the Gibraltar Range (GD pers. obs.). The detection of *L. subglandulosa* and *P. pughi* currently represents the north-western limit of the species distribution (Ehmann 1997, Knowles *et al.*, 2004, Anstis 2002).

Conclusion

This study was undertaken as a component for an environmental impact statement to assess the impact of logging on fauna and flora within the Tenterfield management (Tanton 1995). Our work systematically quantified the density of various species of reptile and provides a baseline on the distribution of reptiles and amphibians within the region that can be used for comparisons in later studies.

Acknowledgements

We thank M. Coombe (District Forester) for information on logging regimes and R. Goldingay for his contributions of opportunistic observations in the field. Harry Hines and Dave Newell reviewed the manuscript and their comments greatly improved this paper. Staff of the Department of Environment, Climate Change and Water provided records from the wildlife atlas.

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APPENDIX 1

Appendix 1. Location of sites surveyed.

AMG Datum 66, UTM co-ordinates in Zone 56. Note numbering of sites consistent with Tanton (1995).

Site	Location	Topographic map	Easting	Northing	Logging history	Forest type	Altitude (m)
1	Girard SF	Drake	433900	6796400	UL	CF	965
2	Girard SF	Drake	434500	6795600	UL	CF	900
3	Girard SF	Drake	433800	6794800	UL	MH	660
4	Girard SF	Drake	433050	6794800	UL	MH	570
5	Girard SF	Drake	431550	6796060	HL	MH	840
6	Girard SF	Drake	431100	6797050	HL	MH	770
7	Girard SF	Drake	432100	6795050	UL	MH	570
8	Forest Land SF	Spirabo	414500	6760200	UL	CF	1040
9	Forest Land SF	Spirabo	414600	6759600	SL	MT	1015
10	Forest Land SF	Liston	413800	6774000	UL	CF	1050
11	Bookookoorara	Sandy Flat	418200	6829500	HL	MT	875
12	Forest Land SF	Spirabo	415600	6777500	SL	MT	975
13	Spirabo SF	Spirabo	418200	6757700	HL	MT	985
14	Spirabo SF	Spirabo	419100	6753600	UL	MT	1130
15	Spirabo SF	Spirabo	418200	6754900	UL	MT	1140
16	Forest Land SF	Spirabo	410900	6755900	UL	MT	1070
17	Spirabo SF	Spirabo	417300	6756900	UL	DT	1140
18	Boorook SF	Bookookoorara	420300	6814100	UL	MT	945
19	Boorook SF	Bookookoorara	419500	6812400	UL	DT	930
20	Malara SF	Bulldog Rock	427200	6787100	HL	DT	1035
21	Boorook SF	Bookookoorara	419200	6810900	HL	DT	980
22	Boonoo SF	Boonoo Boonoo	416400	6798100	UL	DT	1105
23	Boonoo SF	Boonoo Boonoo	419100	6800100	HL	DT	1020
24	Boonoo SF	Bookookoorara	420200	6813200	UL	MH	870
25	Jenner SF	Bookookoorara	409000	6815500	HL	DT	975
26	Gilgurry SF	Pretty Gully	429300	6810400	SL	DC	690
27	Gilgurry SF	Pretty Gully	430000	6811700	SL	DC	680
28	Forest Land	Sandy Flat	414900	6776500	SL	MT	1050
29	Forest Land	Sandy Flat	414800	6774750	SL	MT	1070
30	Girard extension	Drake	446500	6792900	UL	DC	560
31	Girard extension	Drake	447050	6793100	UL	DC	430
32	Boorook SF	Bookookoorara	420250	6812600	SL	MH	905
33	Malara SF	Bulldog Rock	428800	6788100	SL	MH	950
34	Boonoo SF	Boonoo Boonoo	420300	6800100	HL	MT	920
35	Spirabo SF	Spirabo	419400	6752800	HL	MT	1080

APPENDIX 2

Appendix 2. Species of reptile and amphibian recorded from various surveys from within State Forests of the Tenterfield Management Area

Note: 1 = this study, 2 = Hines (1991 and 1993/1994 unpublished data), 3 = NPWS Wildlife Atlas records searched between co-ordinates (AMG 66 datum) 409000 to 447100 (easting) and 6752800 to 6829500 (northing)

Note 2: recent taxonomic changes post 1992 such as Sadlier *et al.* (1993), Frost *et al.* (2006), Gardner ***et al.*** (2008), Knowles *et al.* (2004) are adhered. *Litoria piperita* is considered a colour morph of *L. barringtonensis*. Hines (1991) record of *Philoria kundagungan* is considered to represent *Philoria pughi* on range and taxonomic revision of the genus (Knowles *et al.* 2004).

Family	Species	Common name	Bookookoorara	Boonoo	Boorook	Forest land	Gilgurry	Girard	Girard ext	Jenner	Malara	Spirabo	Wildlife atlas records
Chelonidae	*Chelodina longicollis*	Eastern Snake-necked Turtle											*
	Emydura macquarii signata	Brisbane River Turtle											*
Varanidae	*Varanus varius*	Lace Monitor			2				1				*
	Varanus gouldii	Gould's Goanna											*
Gekkonidae	*Oedura robusta*	Robust Velvet Gecko											*
	Oedura tryoni	Spotted Velvet Gecko				1							*
	Saltuarius wyberba	Northern Leaf-tailed Gecko				2							*
Pygopodidae	*Lialis burtonis*	Burton's Snake-lizard											*
	Pygopus lepidopodus	Common Scaly-foot											*
Agamidae	*Amphibolurus muricatus*	Jacky Dragon											*
	Amphibolurus nobbi nobbi	Nobbi Dragon						1				2	*
	Physignathus lesueurii lesueurii	Eastern Water Dragon						1, 2				2	*
	Pogona barbata	Bearded Dragon											*
Scincidae	*Acritoscincus platynota*	Red-throated Skink		1	1						1		*
	Anomalopus leukartii								1				
	Bellatorias major	Land Mullet							1				*
	Bellatorias frerei	Major Skink											*
	Calyptotis scutirostrum	Scute-snouted Calyptotis	1	1	1, 2	1	1	1, 2	1	1	1	2	*
	Carlia vivax	Tussock Rainbow-skink											*
	Coeranoscincus reticulatus	Three-toed Snake-tooth Skink											*
	Cryptoblepharus virgatus	Cream-striped Shinning-skink											*

APPENDIX 2

Family	Species	Common name	Bookookoorara	Boonoo	Boorook	Forest land	Gilgurry	Girard	Girard ext	Jenner	Malara	Spirabo	Wildlife atlas records
	Ctenotus eurydice	Brown-backed Ctenotus											*
	Ctenotus robustus	Striped Skink											*
	Ctenotus taeniolatus	Copper-tailed Skink		1									*
	Cyclodomorphus gerrardii	Pink-tongued Lizard											*
	Egernia cunninghami	Cunningham Skink		1							1		*
	Egernia mcpheei	McPhee Rock Skink		1			1	1			1	1	*
	Eulamprus kosciuskoi	Alpine Water Skink											*
	Eulamprus martini	Dark Bar-sided Skink		1	1, 2		1	1	1	1	1		*
	Eulamprus murrayi	Blue-flecked Forest Skink			2	1		1				1, 2	*
	Eulamprus quoyii	Eastern Water-skink		1	2	1		2				1, 2	*
	Eulamprus tenuis	Barred-sided skink					1						*
	Lampropholis amicula	Small Grass Skink						1					*
	Lampropholis delicata	Grass Skink	1	1	1, 2	1	1, 2	1	1	1	1	1, 2	*
	Lampropholis guichenoti	Garden Skink			1						1		*
	Liopholis whitii	Whites Skink		1	1								*
	Lygisaurus foliorum	Tree-base Litter-skink											*
	Saiphos equalis	Three-toed Skink		1	1, 2	1	1			1		1, 2	*
	Saproscincus rosei	Orange-tailed Skink	1		1	1		1				1, 2	*
	Saproscincus mustelina	Weasel Skink				1							
	Tiliqua scincoides	Blue Tongue Skink											*
Boidae	*Morelia spilota variegata*	Carpet Python						1					*
Colubridae	*Boiga irregularis*	Brown Tree Snake											*
	Dendrelaphis punctulatus	Common Tree Snake											*
Elapidae	*Acanthopis antarcticus*	Death Adder											*
	Austrelaps superbus	Lowland Copperhead											*
	Cacophis krefftii	Dwarf Crown Snake			2			2				1	*
	Cacophis squamulosus	Golden Crown Snake					1					1	*

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Family	Species	Common name	Bookookoorara	Boonoo	Boorook	Forest land	Gilgurry	Girard	Girard ext	Jenner	Malara	Spirabo	Wildlife atlas records
	Demansia psammophis	Yellow-faced Whip Snake											*
	Drysdalia rhodogaster	Masters Snake				1							
	Furina diadema	Red-naped Snake											*
	Hemiaspis signata	Swamp Snake	1			1						1	*
	Hoplocephalus stephensii	Stephens' Banded Snake											*
	Parasuta dwyeri	Dwyer's Snake											*
	Notechis scutatus	Eastern Tiger Snake											*
	Pseudechis porphyriacus	Red-bellied Black Snake			2			2					*
	Pseudonaja textilis	Eastern Brown Snake											*
	Rhinoplocephalus nigrescens	Small-eyed Snake			1	1							*
	Tropidechis carinatus	Rough-scaled Snake											*
	Vermicella annulata	Bandy-bandy											*
Typhlopidae	*Ramphotyphlops nigrescens*	Black Blind Snake			1								*
	Ramphotyphlops proximus	Proximus Blind Snake											*
		Total Species	**4**	**10**	**10**	**8**	**7**	**7**	**5**	**4**	**7**	**9**	
Hylidae	*Litoria barringtonensis*	Cascade Tree Frog						2					*
	Litoria brevipalmata	Green-thighed Frog											*
	Litoria caerulea	Green Tree Frog											*
	Litoria chloris	Red-eyed Tree Frog						1, 2					*
	Litoria dentata	Bleating Tree Frog			1	1	1	2	1				*
	Litoria fallax	Dwarf Tree Frog			2			2	1				*
	Litoria freycineti	Freycinet's Frog											*
	Litoria gracilenta	Dainty Green Tree Frog											*
	Litoria latopalmata	Broad-palmed Frog		1									*
	Litoria peronii	Peron's Tree Frog		1		1		1, 2					*
	Litoria revelata	Revealed Frog											*
	Litoria subglandulosa	Glandular Frog										1	*
	Litoria tyleri	Tyler's Tree Frog						2					*

APPENDIX 2

Family	Species	Common name	Bookookoorara	Boonoo	Boorook	Forest land	Gilgurry	Girard	Girard ext	Jenner	Malara	Spirabo	Wildlife atlas records
	Litoria verreauxii	Verreaux's Tree Frog						2					*
	Litoria wilcoxii	Stony-creek Frog			2			1, 2				2	
Limnodynastidae	*Lechriodus fletcheri*	Fletcher's Frog				1, 2		1, 2				1, 2	*
	Limnodynastes dumerilii	Pobblebonk			2	1		2					*
	Limnodynastes ornatus	Ornate Burrowing Frog											*
	Limnodynastes peronii	Striped Marsh Frog				1		1, 2		1			*
	Limnodynastes tasmaniensis	Spotted Grass Frog						2					*
	Limnodynastes terraereginae	Northern Banjo Frog											*
	Philoria kundagungan	Mountain Frog											*
	Philoria loveridgei	Loveridge's Frog											*
	Philoria pughi	Pugh's Frog										1, 2	*
Myobatrachidae	*Adelotus brevis*	Tusk Frog			2								*
	Assa darlingtoni	Pouched Frog											*
	Crinia parinsignifera	Eastern Sign-bearing Frog		1		1		1, 2					*
	Crinia signifera	Common Eastern Froglet		1	1	1		1, 2					*
	Mixophyes balbus	Stuttering Barred Frog						2					*
	Mixophyes facsiolatus	Great Barred Frog				1		1, 2					*
	Mixophyes iteratus	Giant Barred Frog											*
	Neobatrachus sudellii	Sudell's Frog											*
	Pseudophryne bibronii	Bibron's Toadlet											*
	Pseudophryne coriacea	Red-backed Toadlet			1, 2	1		1, 2				1, 2	*
	Uperoleia fusca	Dusky Toadlet						2					*
	Uperoleia laevigata	Smooth Toadlet		1		1							*
Bufonidae	*Bufo marinus*	Cane Toad											*
		Total Species		5	3	1	1	9	2	1		4	